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ORIGINAL ARTICLE

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Observational study of changes in epidural pressure and elastance during epidural blood patch in obstetric patients

S.D. Pratt, D.W. Kaczka, P.E. Hess
Department of Anesthesia, Critical Care and Pain Medicine, Harvard Medical School, Beth Israel Deaconess Medical Center, Boston, MA, USA

ABSTRACT
Background: During an epidural blood patch, we inject blood until the patient describes mild back pressure, often leading to injection of more than 20 mL of blood. We undertook this study to measure the epidural pressures generated during an epidural blood patch and to identify the impact of volume on epidural elastance in obstetric patients.
Methods: This study was performed in postpartum patients who presented for an epidural blood patch with symptoms consistent with a postdural puncture headache. After identification of the epidural space using loss of resistance to air or saline, we measured static epidural pressure after each 5-mL injection of blood. Models were then fitted to the data and the epidural elastance and compliance calculated.
Results: Eighteen blood patches were performed on 17 patients. The mean final volume injected was 18.9 ± 7.8 mL [range 6–38 mL]. The mean final pressure generated was 13.1 ± 13.4 mmHg [range 2–56 mmHg]. A curvilinear relationship existed between volume injected and pressure, which was described by two models: (1) pressure $= 0.0254 \times (\text{mL injected})^2 + 0.0297$ mL, or (2) pressure $= 0.0679 \times \text{mL}^{1.742}$. The value for r^2 was approximately 0.57 for both models. We found no correlation between the final pressure generated and the success of the epidural blood patch.
Conclusions: We found a curvilinear relationship between the volume of blood injected during an epidural blood patch and the pressure generated in the epidural space. However, there was a large variation in both the volume of blood and the epidural pressure generated. The clinical importance of this finding is not known. A larger study would be required to demonstrate whether pressure is a predictor of success.

Keywords: Compliance; Epidural blood patch; Pressure

Introduction

The epidural blood patch (EBP) is considered standard for treatment of postdural puncture headache (PDPH).[1,2] It is generally believed that the initial relief of PDPH symptoms following EBP is due to a tamponade effect of the injected blood on the lumbar cerebrospinal fluid (CSF), leading to normalization of CSF pressure.[3,4] This mass effect on the lumbar thecal sac has been demonstrated by magnetic resonance imaging and appears to last for several hours.[4,5] Intracranial pressure (ICP) has been shown to rise after EBP, supporting the hypothesis that an increase in lumbar CSF pressure leads to normalization of ICP and initial relief of the symptoms: permanent relief likely occurs from closure of the dural hole and CSF re-accumulation.[6,7] However, it is not known what pressures are generated within the epidural space during the creation of this tamponade. Usubiaga et al. demonstrated that rapid injection of saline 20 mL into the epidural space increased both lumbar subarachnoid and epidural pressures to as high as 850 mmH_2O (equivalent to approximately 65 mmHg).[8] Coombs and Hooper measured subarachnoid pressures following injection of up to 15 mL of blood for therapeutic EBP;[9] using a slow injection, they found a maximum increase of 152 mmH_2O (approximately 11.2 mmHg) in subarachnoid pressure.

The appropriate volume of blood to inject during EBP has not been established. To date, epidural pressures generated when blood volumes >20 mL are injected for EBP and the relationship between injected volume and the resulting pressure have not been reported. Our usual practice when performing an EBP has been to inject blood into the epidural space until the patient describes mild back pressure, which frequently leads to the injection of volumes >20 mL. The purpose of this observational study was to measure epidural pressures during EBP in obstetric patients, and to determine the correlation between the injected volume and these pressures.

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Correspondence to: Stephen Pratt, MD, Beth Israel Deaconess Medical Center, 330 Brookline Ave, Boston, MA 02215, USA.
E-mail address: spratt@bidmc.harvard.edu

Methods

This was a prospective, observational study performed between November 1996 and December 1997. The Committee for Clinical Investigations at Beth Israel Hospital provided full ethical and scientific review, and final approval of the protocol and informed consent document. Written informed consent was obtained from a convenience sample of obstetric patients who had symptoms consistent with a PDPH after neuraxial anesthesia and requested an EBP. As this was a purely observational study, no power calculation was determined. The study was arbitrarily terminated after 14 months. The EBP was performed in our standard fashion, with sterile preparation and draping of the arm for phlebotomy and of the back for the epidural procedure. The phlebotomist initially obtained 20 mL of blood, withdrew an additional 20 mL while the first aliquot was injected, and withdrew a final 20 mL in case pressure sensation in the back was not reached within 40 mL. All procedures were performed with the patient in the left lateral decubitus position. After identification of the epidural space with a 17-gauge Tuohy needle (Smiths Medical, Keene, NH, USA) using loss of resistance to saline or air, a sterile three-way stopcock was placed on the end of the Tuohy needle. An attending anesthesiologist, or senior resident under direct supervision of an attending anesthesiologist, performed all EBP procedures. One port of the stopcock was connected to a strain-gauge pressure transducer using sterile non-compressible tubing flushed with non-heparinized saline (Transpac IV, Hospira, Lake Forest, IL, USA) (Fig. 1). Initial pressure in the epidural space for each patient was defined as the zero point before the injection of any blood. The stopcock was closed to the transducer during blood injection and was then switched open to the transducer and epidural space, but closed to epidural syringe, to measure epidural pressure following injection of each 5-mL aliquot of blood. The pressure tracing was allowed to equilibrate until no perceptible changes in the pressure tracing could be seen, which generally occurred within several seconds. This was recorded as the steady state pressure. This was repeated for every 5 mL injected until the patient experienced mild back pressure or discomfort. If this discomfort occurred in the middle of a 5-mL injection, a final pressure reading was obtained and the total volume noted. After completion of the EBP, the patient was asked to sit up in bed for several minutes to assess the initial efficacy of the injection. This was categorized as ''complete initial relief'', ''partial initial relief'' or ''no improvement''.

Statistical analysis

The relationship between the final volume injected or the epidural pressure generated, and the initial efficacy of the EBP was determined using logistic regression. The resulting epidural pressure as a function of volume for all patients were combined in aggregate, and fitted to the quadratic relationship:

$$P(V) = AV^2 + BV \tag{1}$$

and to the power law relationship:

$$P(V) = CV^D \tag{2}$$

where P denotes the epidural pressure referenced from baseline, and V is the cumulative volume of injected blood. The coefficients for Eq. (1) (A and B) were estimated using a linear least squares technique, while those of Eq. (2) (C and D) were obtained using a nonlinear gradient search algorithm (SigmaPlot version 11.0, Systat Software, Inc., Chicago, IL, USA). For both equations, we computed the coefficient of determination (r^2). The correlation was considered statistically significant for $P < 0.05$. Statistical comparison between the two models was made using the corrected Akaike Information Criterion (AICc).[10] The Intraclass Correlation Coefficient (ICC) using the volume injected as the class was determined in order to assess the degree of consistency in the grouping of pressures generated at each volume.

The epidural elastance E (mmHg·mL^{-1}) as a function of injected volume V (mL) was determined according to the derivative of pressure with respect to volume for each model (Eqs. (3) and (4), respectively):

$$E(V) = \frac{dP}{dV} = 2AV + B \tag{3}$$

$$E(V) = \frac{dP}{dV} = CDV^{D-1} \tag{4}$$

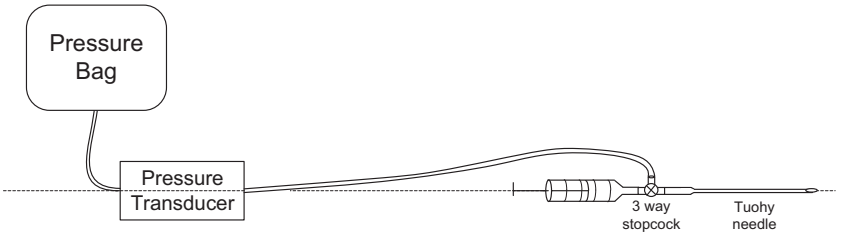

Fig. 1 Schematic diagram of experimental arrangement. See text for details.